Forest fires and climate change: 
Present and future evolution in 
Galicia (NW Spain)

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36% low severity
55% medium-high severity
9% high severity

NBR AND BAI COMBINED
Estimated economic losses derivated from 2006 summer forest fires

Similar to those derivated from the “Prestige” 1.9 % Galician GNP

* Direct losses \( \approx 851.10^6 \) €

* Medium term effects \( \approx 1800.10^6 \) €:
  - Agriculture \( 245.10^6 \) €
  - Tourism \( 90.10^6 \) €

Fire fighting systems costs grew to \( 120.10^6 \) €
Climate change may increase forest fires and the emissions of greenhouse gases.

- Air temperature increase
- Precipitation decrease
- Evapotranspiration increase

Increase of fuels flammability and fuel loads

- Increases CO2, N oxides, CH4...
- Particulated materials

Forest Fires

Greenhouse gases emissions
Forest fires danger indices summarize different information relative to fire risk in an area.

Forest fire danger indices are based on meteorological information that influence fire initiation and propagation.
We have explored the sensibility of two types of indices: Dead and downed fine fuels moisture estimators. Their inputs are air relative humidity and temperature.
The second group of indices also take into account the precipitation and evaporation.

BEHAVE, Canadian Forest Fire Danger Rating System components:
- Precipitation
- Evaporation
- Temperature
- Relative humidity
- Fresh litter (L)
- Partially decomposed litter (F)
- Humus (H)
- Down and dead fine fuels
Fire weather observations

- Air Temperature
- Relative Humidity
- Wind velocity
- Precipitation

Fuel moisture codes

- Fine dead fuel moisture code (FFMC)
- Duff moisture code (DMC)
- Drought code (DC)

Fire behaviour indices

- Initial Spread Index (ISI)
- Buildup Index (BUI)

Van Wagner (1987)
Canadian Forestry Service (1984; 1987)

Fire Weather Index (FWI)
Meteorological information for historical trend analysis

Daily values for March, June, July and August
Forest fire season has been anticipated and the bimodal distribution of fires is accelerated in the last decades.
Dead fine fuel moisture estimator

$y = -0.0103x + 11.97$

$r^2 = 0.07$
Dead fine fuel moisture estimator

$y = -0.0331x + 13.076$

$r^2 = 0.33$
Duff and soil surface moisture estimator

\[ y = 9.4143x + 246.99 \]

\[ r^2 = 0.537 \]
Duff and soil surface moisture estimator
HISTORICAL TRENDS

A trend to more favourable conditions for forest fires was detected in two main directions. From North to South, with worse conditions at lesser latitudes and from higher fire risk from West to East.
A climate model HADCM3, with a scenario of emissions A1B was used to evaluate the impact of climate change on forest fire risk through the use of forest fire danger indices for the period 2000-2060.
• Predicted dead fine fuels moisture content values were lower than those observed for the period 1973-2006.
## Prediction of Number of Forest Fires Using PLS Regression

<table>
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<th></th>
<th>MAR</th>
<th>JUN</th>
<th>JUL</th>
<th>AUG</th>
<th>SEP</th>
<th>Summer</th>
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<td>$Q^2 \text{ acum}$</td>
<td>0.661</td>
<td>0.584</td>
<td>0.455</td>
<td>0.681</td>
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<td>$R^2Y \text{ acum}$</td>
<td>0.742</td>
<td>0.619</td>
<td>0.516</td>
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<td>$R^2X \text{ acum}$</td>
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<td>$FFMC$</td>
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<tr>
<td>$DC$</td>
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<tr>
<td>$ISI$</td>
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<td>$BUI$</td>
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<td>$FWI$</td>
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<td>0.204</td>
<td>0.174</td>
<td>0.162</td>
<td>0.194</td>
<td>0.148</td>
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</table>
Predicted trend in the number of fires
Most of the components of the Canadian Fire Danger Rating System changed from low risk to medium risk and from medium risk to high risk.
No significant Trend

Significant Trend (p < 0.001).
Slope = 0.03 kg/m²/year
**Behave Plus**

**Historical Data:** 1973-2006

**Predicted Data:** 2000-2060

![Fireline Intensity (KW/m) vs. Fuel Model](chart.png)

- **Fuel model 4**
- **Fuel model 7**
- **Fuel model 9**

**Maximum**

**Average**

**Minimum**
CONCLUSIONS

*Forest fire danger indices clearly showed a trend to worse conditions for fire initiation and propagation in Galicia in the last decades.

We can conclude that they are probably reflecting the consequences of global warming.
• The fuel moisture estimators were the group of forest fire danger indices that most clearly evidenced climate change trends.

• Climatic simulation showed an increase of fire risk for the future decades in Galicia.

• The number of days with high fire risk is expected to substantially increase in the period 2000-2060.
Fire behaviour simulations in the future scenarios showed that the current investment in forest fire protection is likely to have to increase in the future and...
Climate change will demand a new silviculture (fuel management) to reduce the probability of high intensity fires.
THANKS!